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REPLY TO LETTER TO THE EDITOR

Baseline time accounting–reply to the letter to the editor of Martin [Int J Life Cycle Assess (2013) 18(7):1279]

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After becoming aware of a letter to the editor from Martin (2013), we realize there is a need for further elaboration of the baseline time accounting method laid out in Kløverpris and Mueller (2013). In the following, we address Martin's comments.

Martin states that our method "*does not eliminate the need to choose a timeframe*." This is correct and inherent to any life cycle assessment (LCA) when it comes to the use of global warming potentials (GWPs). Later, Martin states that we assert that our "*approach removes the need to consider arbitrary timeframes*." We are puzzled by this statement since Sect. 2.3 of our paper explicitly acknowledges that the use of the common 100-year GWP accounting period in LCA is indeed arbitrary. While we cannot avoid this circumstance, our method does eliminate the need to consider an arbitrary *production period* for biofuels (under the conditions described). We will later get back to the fundamental difference between the GWP accounting period and the assumed biofuels production period since the missing distinction between these two time perspectives appears to be the primary basis of Martin's critique.

Martin states that the value of our insights "*is diminished by the failure to include a full consideration of the importance of the timeframe of the analysis*." While we (and the three reviewers) did not find it relevant to include results other than GWP100 in our paper, the baseline time accounting concept is not restricted to this metric. To accommodate Martin, Table 1 shows results for GWP20 and (the more unusual) GWP30.[1] As shown in the table, the applied GWP accounting period is certainly of significance for the type of indirect land use change (ILUC) called accelerated expansion. Meanwhile, the sensitivity to the choice of GWP accounting period is not unique as indicated by the GWPs for methane, also included in Table 1.

For the type of ILUC called delayed reversion, the GWP accounting period is without significance. We acknowledge that this is due to the simplified assumption of constant carbon sequestration over the GWP accounting period. In reality, there will be some sensitivity to the choice of GWP accounting period for delayed reversion but not to the same extent as for accelerated expansion. For additional discussion, we refer to Sect. 4.1.2 in Electronic supplementary material 1 of Kløverpris and Mueller (2013), particularly.

Martin states that "*The baseline time accounting approach uses a 100-year timeframe*," but, as mentioned above, there is no conceptual or methodological restriction on the chosen GWP accounting period. More correctly stated, baseline time accounting converts a time shift in land use emissions from a single batch of biofuels into an ILUC factor that is consistent with the GWP concept, and the results presented by Kløverpris and Mueller (2013) are based on a GWP accounting period of 100 years. The chosen GWP accounting period ensures consistency with the common global warming metric used for greenhouse gas (GHG) emissions. Since the ILUC factor is meant to be added to the GHG emissions from the biofuels supply chain, consistency between addends is necessary.

Martin states that "*It should come as no great surprise that changing the denominator of a fraction from 30 to 100*

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[1] We did not include a GWP500 as this would require a substantial extension of the spreadsheet model published as part of our paper and additional assumptions regarding carbon sequestration profiles.

Table 1 Estimated ILUC factors for US corn ethanol and GWP values for methane (the latter based on IPCC 2007)

	Unit	Annualization	Baseline time accounting		
		30 years	GWP20	GWP30	GWP100
Searchinger study					
Developing world (acc. exp.)	g CO_2e/MJ	78	133	85	24
Developed world (del. rev.)	g CO_2e/MJ	26	6	6	6
Total	g CO_2e/MJ	104	139	91	30
Hertel study					
Developing world (acc. exp.)	g CO_2e/MJ	3	5	3	1
Developed world (del. rev.)	g CO_2e/MJ	23	10	10	10
Total	g CO_2e/MJ	27	15	13	11
Methane					
Total	g CO_2e/g	N/A	72	58	25

reduces that number by 70 %." While this is universally true, it is not a proper way to explain the difference between our results (based on a 100-year GWP accounting period) and the ILUC factors obtained with the 30-year annualization method. The key here is the distinction between the *biofuels production period* (or more generally, *the temporal scope of an LCA*) and the *GWP accounting period* applied for radiative phenomena (be it GHG emissions, time shifts in land conversion, albedo change, or something else). In many LCAs, production period assumptions are not of high importance mainly because GHG emissions occur approximately at the same time. For instance, the assessment of the climate impact of replacing a plastic container with a metal container does not require elaborate considerations about production periods because these would be relatively short. Still, the GHG emissions from the two life cycles would typically be measured by their GWP100. In a slightly more complex example, consider the climate impact of driving a car and the contribution from the steel in the car. In this case, you would typically distribute the steel emissions over the entire service provided by the car, i.e., the total numbers of kilometers driven over its lifespan, say 15 years. Still, the GHG emissions would typically be measured by their GWP100. As for the ILUC analyses by Searchinger et al. (2008) and Hertel et al. (2010), they chose to look at 30 years of biofuels production and then distributed land use emissions from an assumed one-time land conversion over the volume of biofuels produced during those 30 years. Still, the resulting ILUC factors were derived with the purpose of adding them to other GHG emissions from corn ethanol, typically measured by their GWP100. The key point here is that there is a fundamental difference between temporal considerations regarding lifespan or production periods and the GWP accounting period applied for radiative phenomena in an LCA. One of the main reasons is that an LCA typically considers the long-term implications of the changes studied within a given temporal scope. For the same reason, it is incorrect to assume that an ILUC factor derived with the baseline time accounting method and based on a 30 year *GWP accounting period* would be "consistent" with the Searchinger and Hertel analyses just because they assume a 30-year *production period*. The only logical justification for deriving an ILUC factor with the baseline time accounting method based on a 30-year GWP accounting period would be to use this ILUC factor in an LCA with GWP30 as the common metric for all biofuels emissions (and replaced fossil fuel emissions, for that sake). We are not aware of any such LCAs.

Martin states that we justify our "*decision to use the global warming potential based on a 100-year timeframe (GWP100)*" with "*consistency between the ILUC factor estimation and the GWP concept*." However, our paper repeatedly states that our method is based on consistency with the GWP approach (regardless of the chosen accounting period), and that we chose to present *results* as GWP100 because that seemed most relevant.

Martin states that "*100 years is certainly not the only timeframe that is routinely used in GWP analyses*." While the Intergovernmental Planet on Climate Change publishes GWP values for GHGs with accounting periods of 20, 100, and 500 years, we are not aware of any major biofuels legislation that does not apply the GWP100 metric for GHG emissions. This goes for the US Renewable Fuel Standard, EU's Renewable Energy Directive, and California's Low Carbon Fuel Standard. It also goes for the GREET Model (Argonne National Laboratory 2013), the Greenhouse Gas Protocol (WRI/WBCSD 2011), PAS 2050 (BSI 2011), and many other tools and standards. We have however, as already mentioned, presented results in Table 1 for GWP20 and GWP30 to allow for analyses with short GWP accounting periods. It is obviously important to keep in mind that such analyses ignore long-term effects.

In summary, it is necessary to ensure consistency between ILUC emissions and other GHG emissions in an LCA. Hence, it is vital to apply consistent GWP accounting periods for radiative phenomena and to distinguish this time perspective

from the biofuels production period assumed in the studies by Searchinger et al. (2008) and Hertel et al. (2010). With baseline time accounting, production period considerations become unnecessary under the conditions described in our paper. Meanwhile, the choice of a general GWP accounting period remains inherent to any LCA when it comes to global warming potentials.

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